Geologic Setting of Gold Occurrences in the Big Canyon Area, El Dorado County, California

U.S. GEOLOGICAL SURVEY BULLETIN 1576

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By ROBERT L. EARHART

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Geologic Setting of Gold Occurrences in the Big Canyon Area, El Dorado County, California

By Robert L. Earhart

Abstract

The Big Canyon area is on the eastern margin of the melange belt, which is one of four tectono-stratigraphic belts that trend northerly along the western flank of the Sierra Nevada. The melange belt is separated from the Mother Lode belt to the east by an unnamed fault zone in the eastern part of the study area. The Mother Lode belt contains volcanic, volcaniclastic, and sedimentary rocks of island-arc affinity. The Bear Mountains ophiolite to the west and northwest of the study area contains ultramafic and mafic rocks derived from oceanic crust and upper mantle. The Bear Mountains ophiolite is one of a series of tectonically disrupted ophiolite sequences on the western flank of the Sierra Nevada Mountains.

Gold deposits in the Big Canyon area occur in a melange that consists of lithic fragments derived from oceanic crust and island-arc terranes. Serpentinite and basalt that compose the matrix of the melange are vestiges of dismembered ophiolite. The melange represents deposition in a trench that formed as a result of the subduction of oceanic crust beneath island-arc terrane.

The area contains two distinct types of gold deposits. The older gold deposits are hosted by detached blocks of pyritic chert and associated banded iron-formation. These deposits, formed by sea-floor exhalative processes in an island-arc environment, were moved by gravity to their present chaotic setting during formation of the melange. Younger gold occurrences, including the Big Canyon deposit, are associated with hydrothermally altered fault zones that are younger than the formation of the melange. They are akin to the fault-controlled auriferous quartz veins in the Mother Lode belt east of the Big Canyon area.

Undiscovered deposits similar to those in the Big Canyon area may occur in parts of the 235-mile-long melange belt in the western Sierra Foothills where the geologic environment is similar. Chert and iron formation in island-arc terranes east of the study area, which were the inferred source of the gold-bearing chert blocks, may also be favorable targets for gold exploration.

INTRODUCTION

The Big Canyon area is about 10 mi southeast of Placerville and 4 mi south of Shingle Springs in El Dorado County, California (fig. 1). The area is accessible from Shingle Springs, which is on U.S. Highway 50, via Frenchtown Road, a paved, secondary county road. The area contains two inactive gold mines, the Big Canyon and the Vandalia, as well as numerous gold prospects.

The Big Canyon (Oro Fino) and Vandalia gold deposits were discovered in the mid-1880's. The Big Canyon mine, one of the largest in El Dorado County, produced $720,000 in gold from 1893 to 1901 (Clark and Carlson, 1956). In 1934, the mine was acquired by Mountain Copper Co., and from 1934 to 1940 it produced gold valued at $2,368,000. The mine has been idle since 1940. The Vandalia mine produced minor amounts of ore in 1888, about 1900, and from 1926 to 1928. The mineral rights on both properties were acquired in 1983 by Gold Fields Mining Corp., which reevaluated the gold potential. The work by Gold Fields indicated the presence of additional gold ore of a grade comparable to that mined in the past, between 3 and 7 ppm; however, the tonnage of reserves was not established (R. Ridler, oral commun., 1985).

Gold Fields Mining Corp. provided access to the Vandalia mine and geologic data for the Vandalia and Big Canyon mines to supplement ongoing studies by the U.S. Geological Survey. Mr. Ernest 'Doc' Schieber graciously allowed access to his ranch, on which are situated the Big Canyon Mine and about 70 percent of the map area. The west-central part of the area is on the Doug Albright Ranch and the southern part is on the White Ranch; the landowners are gratefully acknowledged for their help and cooperation. Messrs. Tom Anderson and Ralph Loyd of the California Division of Mines and Geology were particularly helpful during the present studies. I thank them for sharing with me their insight on the geology of the region.

Previous Work

The Sierra Foothills, a major gold-producing region in the past, has been studied by geologists since the late 1800's; however, until recent exploration activities were undertaken by Gold Fields Mining Corp., the rocks in the Big Canyon area of the Foothills region had been neither mapped nor studied in detail. Early workers (Becker, 1885; Turner, 1893;Taliaferro,1942) considered

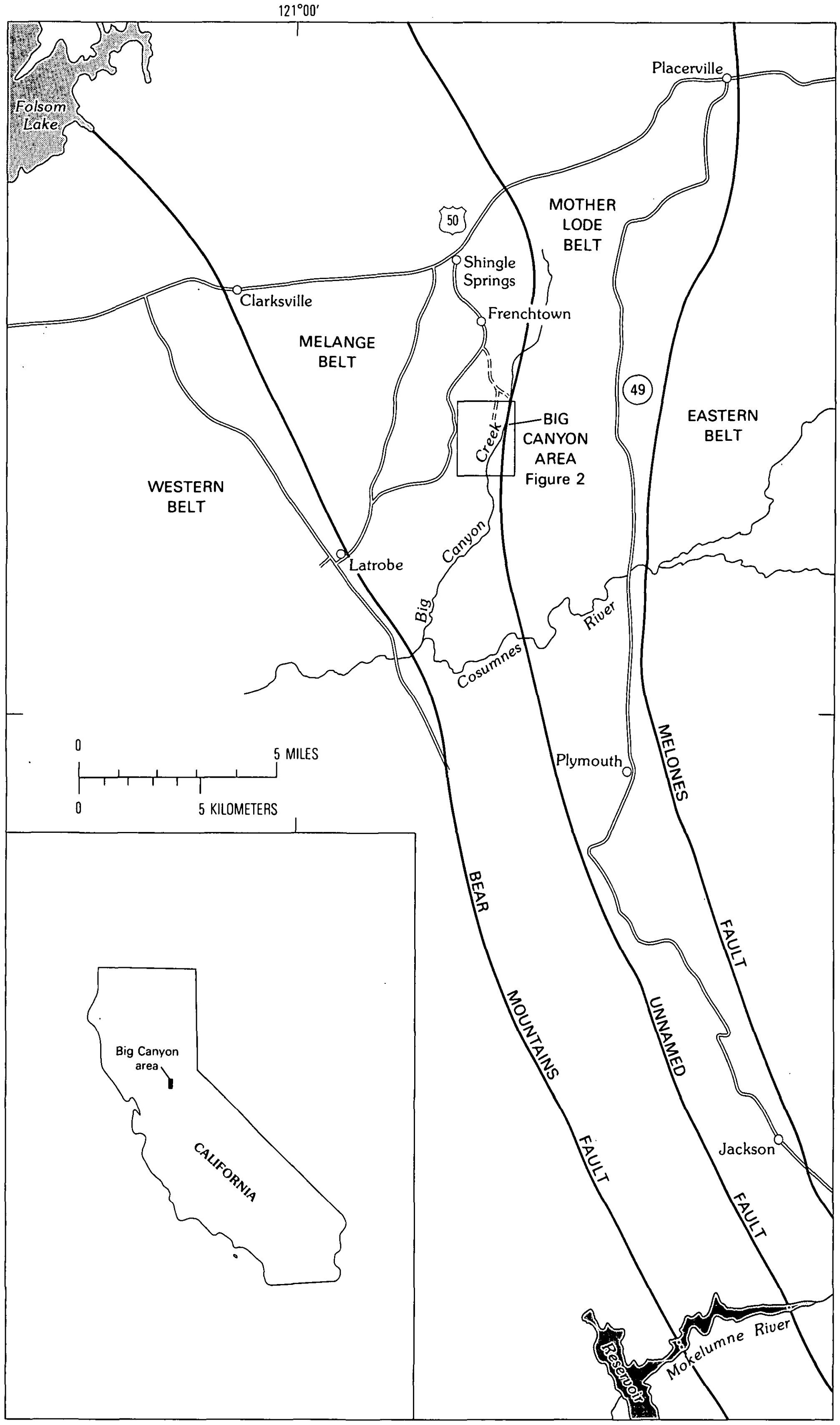


Figure 1. Index map of the central Sierra Foothills, Calif., showing general distribution of tectonostratigraphic belts.

the rocks in the Foothills region to be conformable sedimentary-volcanic sequences, which they divided into three principal stratigraphic units: the Calaveras Formation, the Mariposa Formation, and the Amador Group (now called the Logtown Ridge Formation). Until 1964, most workers in the Foothills correlated the rocks in their study areas with these stratigraphic units or with subdivisions of these units, based on similarities of lithology and metamorphic grade. The results were often ambiguous owing to similar lithologies in various units. Clark (1964) restricted the use of the stratigraphic names to the type localities of the formations and to areas where stratigraphic continuity could be demonstrated.

With the broad acceptance of plate tectonic theory, most modern workers have considered the Foothills region to consist of three or more tectono-stratigraphic belts that were juxtaposed as a result of plate tectonic processes along the western continental margin in the Triassic and Jurassic Periods. Duffield and Sharp (1975), during studies of the Foothills region south of the Cosumnes River, recognized an eastern belt, a Mother Lode belt, a melange belt, and a western belt (fig. 1). The Big Canyon area discussed in this report is in the northern extension of a part of their melange belt. Behrman (1978), who studied the rocks adjacent to the study area, divided the melange belt of Duffield and Sharp into a central belt and a Bear Mountains ophiolite belt. The Bear Mountains ophiolite is one of a series of ophiolite assemblages that trends northerly within or adjacent to the melange belt along the western flank of the Sierra Nevada for about 235 mi. Saleeby (1982) demonstrated that the ophiolites in this belt are tectonically disrupted sequences which have contrasting metamorphic and deformational histories and which range in age from about 300 m.y. to about 150 m.y. For the most part, the rocks in the study area appear to belong to the 300-Ma ophiolite terrane of Saleeby.

Present Investigations

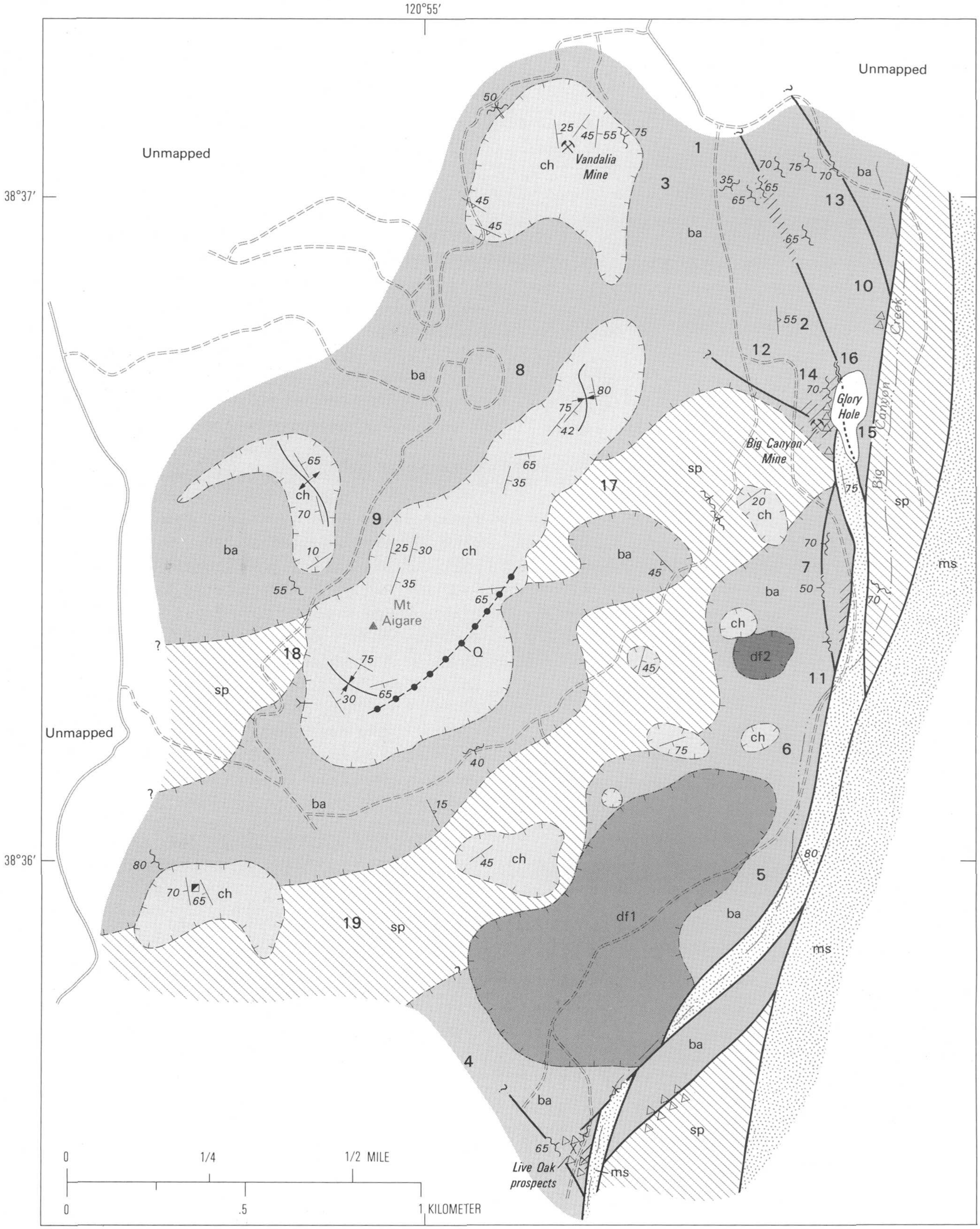
Present investigations by the U.S. Geological Survey were undertaken in order to document the geologic setting, petrography, and geochemistry of gold occurrences in the melange belt. This report describes the geologic setting; petrographic and geochemical studies are still in progress. Past studies of gold occurrences in the Foothills region focused on the Mother Lode belt to the east of the study area (Lindgren and Turner, 1894; Knopf, 1929). The settings of less well documented gold occurrences in the melange belt differ from the auriferous quartz veins and adjacent gray ore zones typical of the Mother Lode belt. The Big Canyon area was mapped during the present studies in 1985 and 1986, and outcrop samples were collected for analysis in order to characterize the rocks in the area. Maps by Mr. Mark W. Osterberg of Gold Fields Mining Corp., which were made available, proved to be invaluable. However, the interpretation of geological data utilized in this study may not reflect the conceptual geologic model favored by Gold Field Mining Corp. geologists familiar with the area.

REGIONAL SETTING

The Big Canyon area is within the Sierra Foothills, which consist of a series of north-trending tectono-stratigraphic belts of metamorphosed sedimentary, volcanic, and intrusive rocks that range in age from late Paleozoic to Mesozoic (fig. 2). Locally, the Mesozoic rocks are capped by erosional remnants of a once-extensive conglomerate and tuff of Tertiary age. The structural belts, which extend for about 235 mi along the western side of the Sierra Nevada, are flanked to the east by the Sierra Nevada batholith and to the west by sedimentary rocks of the Great Valley sequence of Jurassic and Cretaceous ages. The structural belts are internally bounded by the Melones and Bear Mountains faults (Clark, 1964; Duffield and Sharp, 1975). These steeply dipping major faults, along with an unnamed normal fault that parallels Big Canyon Creek in the study area, separate diverse geologic terranes of oceanic-crust and magmatic-arc affinities. All the belts are characterized by extensive faulting, shearing, and folding, and metamorphic grades range from greenschist to amphibolite facies (Clark, 1964).

The following lithologic descriptions from the eastern, Mother Lode, melange, and western belts are mostly summarized from Duffield and Sharp (1975). The eastern belt is dominantly phyllite, phyllonite, and chert of Paleozoic age. The phyllite and phyllonite are dark gray to silver gray and appear similar in outcrop. The chert is mostly thin bedded with phyllite partings and, for the most part, is indistinguishable from chert in the melange belt. Other rocks in the eastern belt include an Upper(?) Jurassic granodiorite pluton near the Cosumnes River and small bodies of Upper(?) Jurassic serpentinite, gabbro, diorite, and limestone. The Paleozoic metasedimentary rocks of the eastern belt have been assigned to the Calaveras Formation by most investigators.

The Melones fault zone separates the eastern belt from the Mother Lode belt, which consists of the Upper Jurassic Logtown Ridge and Upper Jurassic Mariposa Formations. The Logtown Ridge, which at the type locality on the Cosumnes River is about 6,500 ft thick, consists of volcanic and volcanic-sedimentary rocks of island-arc affinity. These rocks are mostly basaltic and include flows, breccias, and a variety of layered pyroclastics, including lapilli tuff. The overlying Mariposa Formation contains a distal-turbidite, hemipelagic sequence


120°55′
38°37′
38°36′
Unmapped
Unmapped
Unmapped
Vandalia Mine
Glory Hole
Big Canyon Mine
Big Canyon Creek
Mt Aigare
Live Oak prospects
ba
ch
sp
ms
df1
df2
Q
1
2
3
4
5
6
7
8
9
10
11
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15
16
17
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19
0
1/4
1/2 MILE
0
.5
1 KILOMETER

EXPLANATION

ch — Chert, banded iron-formation, and felsic tuff

df1 — Debris flow of mostly basaltic rocks

df2 — Debris flow of mostly cherty rocks

ba — Flows, hyaloclastites, pyroclastics, and dikes of basaltic composition

sp — Serpentinite—Includes harzburgite and dunite

ms — Metasedimentary rocks of pelagic affinity—Includes slate and laminated argillite

Inferred contact of olistolith—Hachures in detached block

Strike and dip

65 Beds

55 Foliation

70 Shears

Anticline

Syncline

Inferred fault—Queried where doubtful

Tectonic breccia

Q Quartz vein or stockwork

Carbonate-altered rock

Adit

Shaft or incline

Mine

Prospect

5 Rock sample site

Figure 2 (above and facing page). Geologic map of the Big Canyon area.

of black slate, graywacke, conglomerate, fine-grained tuffaceous rocks, and subvolcanic intrusive rocks. The thickness of the Mariposa is difficult to determine because of structural complexities, but it is probably about 2,600 ft thick at the Cosumnes River.

The Mother Lode belt is separated from the melange belt by an unnamed fault along the eastern margin of the study area (fig. 2). In the vicinity of the study area, the melange belt consists of detached blocks that were derived from oceanic-crust and island-arc terranes. The detached blocks are as much as 2 mi long, in a matrix of mostly serpentinite. The melange, at least in the study area, represents fill in a subduction trench that formed adjacent to an island-arc. In adjacent areas, the melange belt contains epiclastic rocks not present in the study area. The melange belt broadly corresponds to the Sierran ophiolite belt of Saleeby (1982), who subdivided the belt into two groups based on structural setting. As deduced from Saleeby's descriptions, the study area is within his oldest group which yields zircon ages in the 300–200-Ma range. This group crops out locally along the length of the western margin of the Sierra Nevada and constitutes the oldest basement element west of the mountains. Past workers have included the rocks of the melange belt in the Calaveras Formation; most modern workers, however, do not assign this chaotic assemblage to any formation.

The melange belt is separated from the western belt by the Bear Mountains fault. All the rocks in the western belt were assigned to the Upper Jurassic Copper Hill Volcanics by Clark (1964). The Copper Hill Volcanics consist of mafic to felsic flows and pyroclastic rocks that are metamorphosed to greenschist and amphibolite facies. Locally, this formation contains some slaty argillaceous rocks. In general, the Copper Hill Volcanics contain a greater amount of felsic volcanic rocks than do the otherwise similar strata in the Mother Lode belt. The Copper Hill Volcanics are highly deformed and intensely sheared and, according to Duffield and Sharp (1975), may contain tectonic intermixing similar to that found in the melange belt to the east.

GEOLOGY OF THE BIG CANYON AREA

The Big Canyon area contains a melange of detached blocks of debris flow deposits, of banded chert and banded iron-formation (BIF), and of flows, pyroclastics, and hyaloclastites, mostly of basaltic composition. The largest identifiable detached block is the banded chert block that composes Mt. Aigare in the west-central part of the map area (fig. 2). This block is about 1 mi long and as much as 0.4 mi wide; drill hole data indicate that the block is at least 500 ft thick. The detached blocks of banded chert and associated siliceous rock types form prominent peaks and knolls in the area (fig. 3).

The detached blocks are in a matrix that is predominantly peridotite, partly to completely altered to serpentinite, and that also includes basaltic flows and related pyroclastic rocks. Rock types in the matrix are strongly suggestive of an oceanic-crust and upper-mantle protolith and are thought to represent a dismembered and incomplete ophiolite sequence.

The structure within the melange is highly complex. Where exposed, the margins of the detached blocks are seen to be fractured and brecciated. For example, the lower contact between a chert block and serpentinite in the central part of the area is highly fractured and brecciated (fig. 4). Chert breccia fragments are embedded in plastically deformed serpentinite for 2–3 ft below the contact. Blocks of cherty metasedimentary rocks are intensely deformed and contain numerous asymmetric, isoclinal to subisoclinal folds with associated brittle fracturing; the folds were apparently formed during the detachment and emplacement of the blocks in the melange.

Figure 3. Mt. Aigare, center background, is formed from a mile-long detached block of layered chert. Low-lying area in foreground is mostly underlain by serpentinite. View to the west.

After formation of the melange, the rocks were sheared and faulted. To the east, the melange is terminated by a major high-angle fault that parallels Big Canyon Creek (fig. 2). Rocks east of the fault in the study area are mostly slate and argillite of the dominantly volcanic Logtown Ridge Formation. The fault forms the eastern margin of the melange belt and is host to gold deposits at the Big Canyon mine in the northeastern part of the map area and at prospects in the southern part (fig. 2). Prominent shear zones, some of which are altered and mineralized, trend north to northwest in the melange.

The largest and most conspicuous of the detached blocks consist of banded or layered chert and related rocks. This unit is mostly thinly layered to parallel-laminated, light-gray, recrystallized chert and some pink ferruginous chert. The banded appearance of the chert is due primarily to phyllite partings along bedding planes. In the absence of phyllite, the chert appears massive. Locally, the chert contains intercalations of BIF that are as much as 35 ft thick, and that contain as much as an estimated 35 percent magnetite (fig. 5). The magnetite-bearing BIF grades laterally, probably over a few tens of feet, to hematitic ferruginous chert, which in turn grades to nonferruginous chert. In places, the BIF and the ferruginous chert contain as much as an estimated 15 percent layered pyrite, some of which has associated native gold. BIF and pyritic chert are host rocks to gold deposits at the Vandalia mine in the northern part of the area and also at numerous localities elsewhere in the chert blocks (fig. 2). The BIF is not a mappable unit at the scale of figure 2 and is therefore not differentiated from the layered chert unit on the map. It is best developed in the vicinity of a tightly folded syncline northeast of Mt. Aigare and in the vicinity of the Vandalia mine. It also occurs at numerous other chert localities, some of which have been prospected for gold.

In addition to BIF, the chert in the northern part of the map area contains minor interlayers of felsic rock that are interpreted to represent reworked rhyolitic tuff. The felsic rock is weakly sericitic and locally limonitic and has a fine-grained fragmental texture. Adjacent to the study area, chert blocks contain a tuffaceous

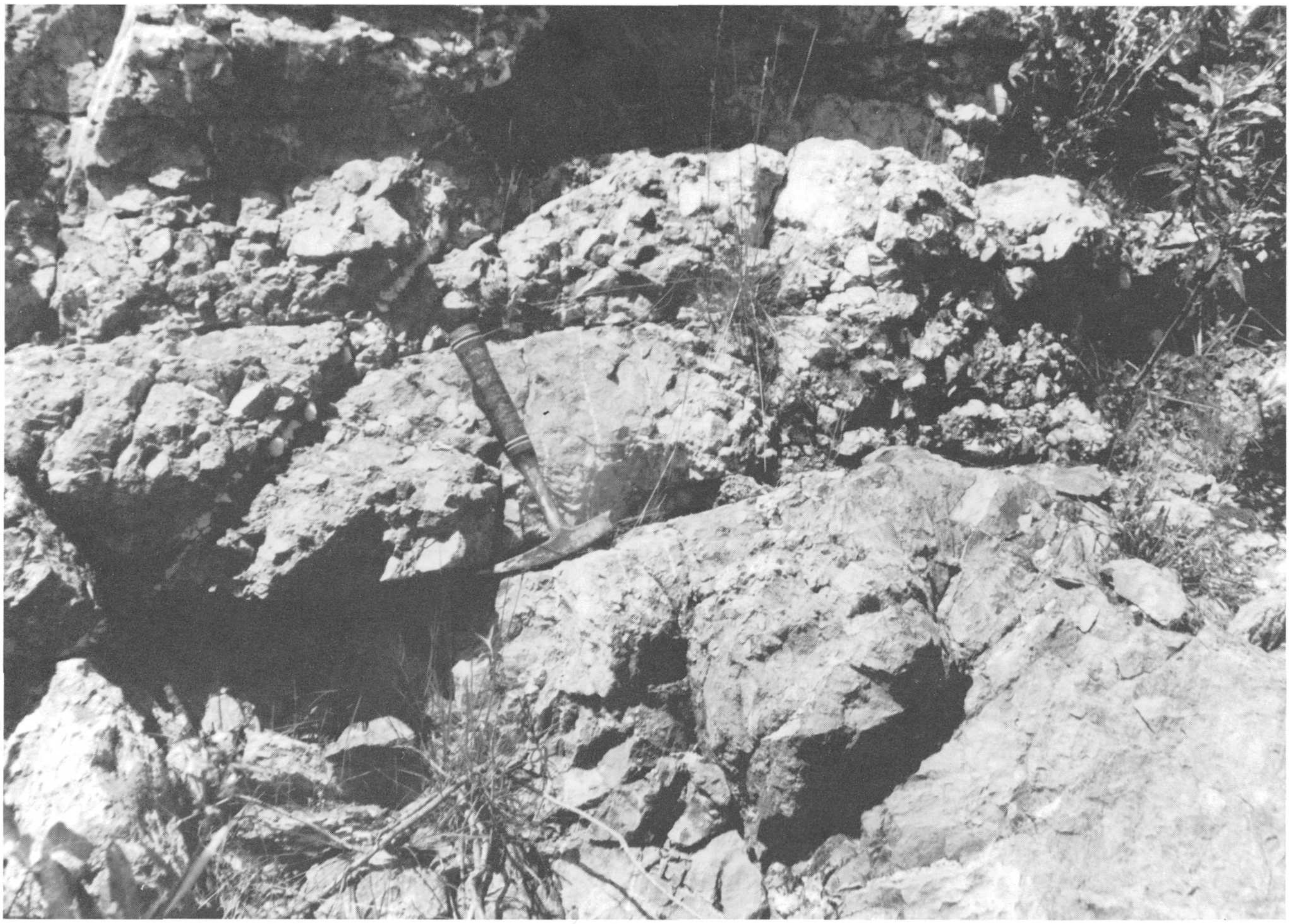

Figure 4. Brecciated chert along lower margin of a detached block overlies serpentinite in the central part of map area.

component that is as much as 40 percent hornblende and epidote and also contain some pelagic metasedimentary rocks (Behrman, 1978).

Within the study area, the chert has abundant veins and stockworks of quartz. Older quartz veins are blue gray, weakly pyritic, and not more than about 2-3 ft thick. Younger quartz is milky white and forms much thicker veins and stockworks. Unlike the quartz veins in the Mother Lode belt to the east, those in the study area are not known to be gold bearing. Although complex folding makes stratigraphic thickness difficult to determine, as much as 2,000 ft of chert may be present in the Mt. Aigare block.

The chert, BIF, and felsic tuff are considered to be more characteristic of chemical sediments and pyroclastics deposited in an island-arc environment than in an ophiolite sequence of a mid-oceanic ridge or a spreading back-arc basin such as represented by the matrix of the melange. Similar chert appears to be part of an island-arc sequence in the foothills to the east of the melange belt; therefore, an island-arc terrane to the east was the likely source of the chert blocks that now occur in the melange belt. Behrman's map shows no chert in the western part of the melange belt, and he observed that the detached blocks of chert become increasingly abundant toward the east—a distribution that further suggests a source to the east (Behrman, 1978).

Detached blocks of coarse debris flow deposits in the study area strongly suggest that the melange formed by gravity depositional processes in a submarine trench. Two types of debris flow deposits are present. One type, shown as df1 on figure 2, consists of randomly oriented fragments of basaltic rocks and minor peridotite (fig. 6*A*). The fragments in this type are of greatly varied size but are rarely more than about 15 in. in diameter. Chert fragments are completely lacking in this type. The clasts are representative of the partial ophiolite assemblage that composes the matrix of the melange. This debris flow deposit probably is derived from oceanic crust on the western side of the subduction trench. A large detached block of this deposit is in the southern part of the map area (fig. 2). The second type of debris flow deposit,

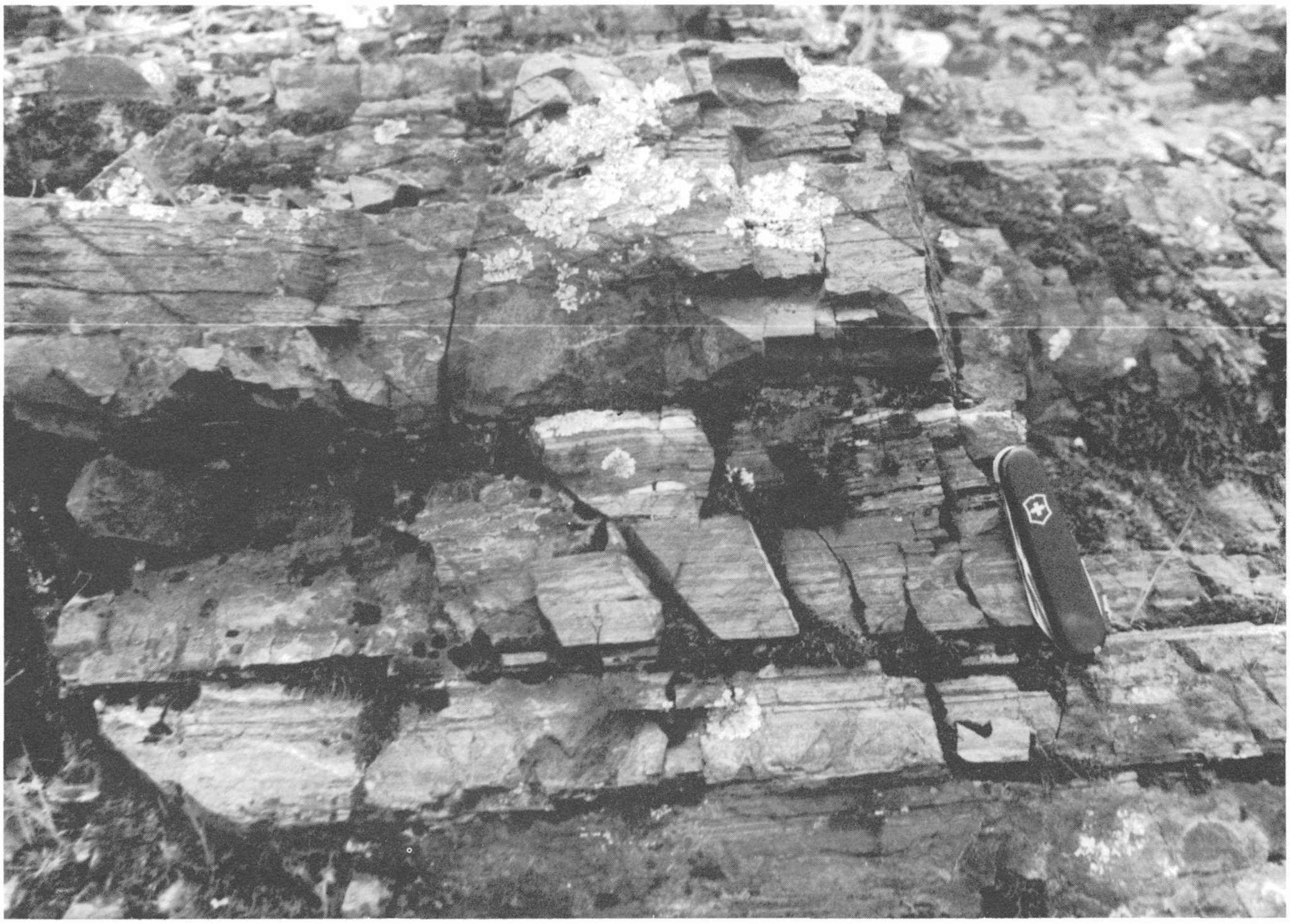

Figure 5. Banded iron-formation on ridge north of Mt. Aigare.

shown as df2 on figure 2, consists of about 75 percent chert fragments (fig. 6*B*); other fragments include basalt and exotic metamorphic rocks. Fragments in this type of debris flow deposit are rarely larger than 20 in. in diameter. This type is inferred to represent deposition from source rocks to the east of the trench. A small detached block of df2 crops out to the north of the df1 unit in the east-central part of the map area (fig. 2).

Blocks of basaltic volcanic rocks of olivine tholeiite, tholeiite, and calc-alkalic compositions are also present in the melange. The basaltic rocks are shown as a single unit on figure 2 because it is difficult to differentiate basaltic rocks that are a part of the dismembered ophiolite from those that represent deposition in the subduction trench. In the western part of the area, the basaltic rocks are dominantly pillow lavas (fig. 7). The pillows are commonly rimmed with hyaloclastite, but pyroclastic rocks are rare in this part of the area. Basaltic volcanics in the eastern part of the area include basalt and olivine basalt flows, mafic tuff including lapilli tuff (fig. 8), mafic volcanic breccia, and hyaloclastic material. Pillow structures are rarely discernible in the eastern part of the area, probably due to widespread shearing and faulting. Locally, sheared basaltic rocks in the eastern part are metamorphosed to actinolitic amphibolite, and where the basalts are highly sheared, they are converted to actinolite schist. Amphibolite dikes, which were probably feeder dikes, form resistant outcrops, and locally, chilled dike margins are preserved.

Other rock types not recognized in outcrops were observed by J.T. Nash (written commun., 1986) in drill cores from the eastern part of the area. Analytical results of the drill core samples confirm the presence of small amounts of dacite or rhyodacite, andesite, and vitric tuff, all of which are here inferred to be derived from island-arc terranes to the east. Lapilli tuff that may be similar to that in this area has been described by Duffield and Sharp (1975) from the Logtown Ridge Formation to the southeast of the study area.

The major-element composition of a variety of basaltic rocks in the area is given in table 1. These data show that the low-silica basalts also contain low amounts

Figure 6. Debris flow deposits. *A*, Deposit with predominantly basaltic rock fragments—df1 unit on figure 2. *B*, Deposit with predominantly chert rock fragments—df2 unit on figure 2.

of K_2O and TiO_2 and are chemically similar to olivine tholeiites from most deep sea floor-oceanic ridge environments (Charmichael and others, 1974).

Rocks of ultramafic composition are dominant in the matrix of the melange, and they include serpentinite, talcose serpentinite, partially serpentinized olivine-orthopyroxene rock (harzburgite?), and dunite. The serpentinite is massive and commonly sheared, and it completely lacks relict textures. Talcose serpentinite occurs in intensely sheared zones. Locally the serpentinite contains chrysotile in multiple veinlets as thick as one-quarter inch. Partly serpentinized harzburgite(?) contains relict cumulate texture and thick discontinuous layers that reflect the differential concentration of olivine. Dunite occurs as small, discontinuous to lenticular bodies in harzburgite(?) and is conspicuous by the rusty appearance of the outcrop surface. The compositions of ultramafic rocks in the area are given in table 1 (samples 17, 18, and 19).

Argillaceous and siliceous pelagic metasedimentary rocks occur within and east of the fault zone that parallels Big Canyon Creek and forms the eastern boundary of the melange belt (fig. 2). They are tentatively assigned to the Upper Jurassic Logtown Ridge Formation and may be a basinal facies of the Goat Hill Member of Duffield and Sharp (1975). The Goat Hill Member, where described about 22 mi to the south near the Mokelumne River, consists in large part of well-bedded marine pyroclastic rocks. Near the Big Canyon Creek fault zone in the study area, the member consists of parallel-laminated, gray to greenish-gray argillite with 2–3-mm-thick beds and of dark-gray slate that locally occurs as pencil slate.

CARBONATE ALTERATION

Carbonate rock in the alteration zone by the Glory Hole at the Big Canyon mine is similar to the ophicarbonate described by Behrman (1978) from the melange belt adjacent to the study area. Ophicarbonate is a carbonate-rich rock that has been observed in some

Figure 7. Pillow structures in basalt in western part of area. Hyalaclastic material occurs along pillow margins.

ophiolite sequences and is assumed to be cogenetic with other rocks of the ophiolite suite. The carbonate rock in the study area, however, appears to be younger than the ophiolite. Behrman's mapping shows that carbonate rock occurs exclusively along or near the eastern boundary of the melange belt, and that it is everywhere fault bounded. The carbonate rock at the Big Canyon mine and at other localities in the eastern part of the area is similar in composition and in geologic setting to that described by Behrman. In the study area, carbonate-cemented breccia with basaltic clasts occurs within the fault system that parallels Big Canyon Creek and forms the eastern limit of the melange belt. Calcite also partially replaces sheared basalt in the fault zones. The occurrence of the carbonate rock in cross-cutting fault zones suggests that it is younger than the development of the melange which, in turn, is younger than the formation of the ophiolite. In other areas of similar geologic setting, carbonate is commonly derived from the release of calcium from epidote or other calcium-bearing minerals during serpentinization.

The fault-associated carbonate zones in the study area contain pyrite and free gold as do the fault-associated quartz veins in the Mother Lode belt to the east. According to Landefeld (1985), the quartz veins and associated gold deposits in the Melones fault zone of the Mother Lode belt formed during late-stage brittle faulting in Late Triassic time. A similar origin may be inferred for the gold-bearing carbonate zones of the study area. The fault zone along Big Canyon Creek, however, contains strata of inferred Jurassic age and therefore, the carbonate alteration zones were formed after the emplacement of these strata.

GOLD OCCURRENCES

Gold occurrences in the study area are associated with pyrite and arsenopyrite in highly altered fault zones and with pyrite in banded iron-formation and chert. Eight samples collected from outcrops and surface mine workings in the fault zones during mapping contained as much as 3 ppm gold. Core samples from the fault zone, which were collected and analyzed by Gold Fields Mining Corp., reportedly contain as much as 8.5 ppm gold. Similarly, 19 outcrop and mine samples of BIF and pyritic chert contained as much as 0.7 ppm gold, whereas core samples of these rocks in the vicinity of the Vandalia mine contained as much as 4.2 ppm. Gold-bearing outcrop samples from both types of occurrences contained 1 ppm or less silver.

Big Canyon Mine and Related Occurrences

At the Big Canyon mine, which is the largest producer in the area and one of the largest in the melange belt, gold occurs in a carbonate alteration zone at the intersection of three branching faults which are parts of a major fault zone that parallels Big Canyon Creek (fig. 2). The steeply dipping ore zone is exposed for about 150 ft in a northerly direction along strike on the western side of the Glory Hole. The width is indeterminable owing to scarcity of exposures. The ore zone is on a strike projection of laminated argillite that is part of a sequence of metasedimentary rocks that crop out on the southeastern side of the Glory Hole. The ore evidently occurs along a fault that separates metasedimentary rocks to the east from basalt and basaltic tuff to the west. The host rock is a breccia that contains silcified and pyritized fragments primarily from the basaltic wall rocks. The breccia matrix consists of calcite, ankerite(?), quartz, chlorite, and tremolite. Sulfide minerals occur as disseminations and fracture-fillings in both the matrix and the fragments of the breccia, but are most abundant in the matrix. Surface exposures contain as much as 5 percent sulfides, and intervals of 2–3 ft in the drill core contain as much as 15 percent. Gold values appear to vary directly with

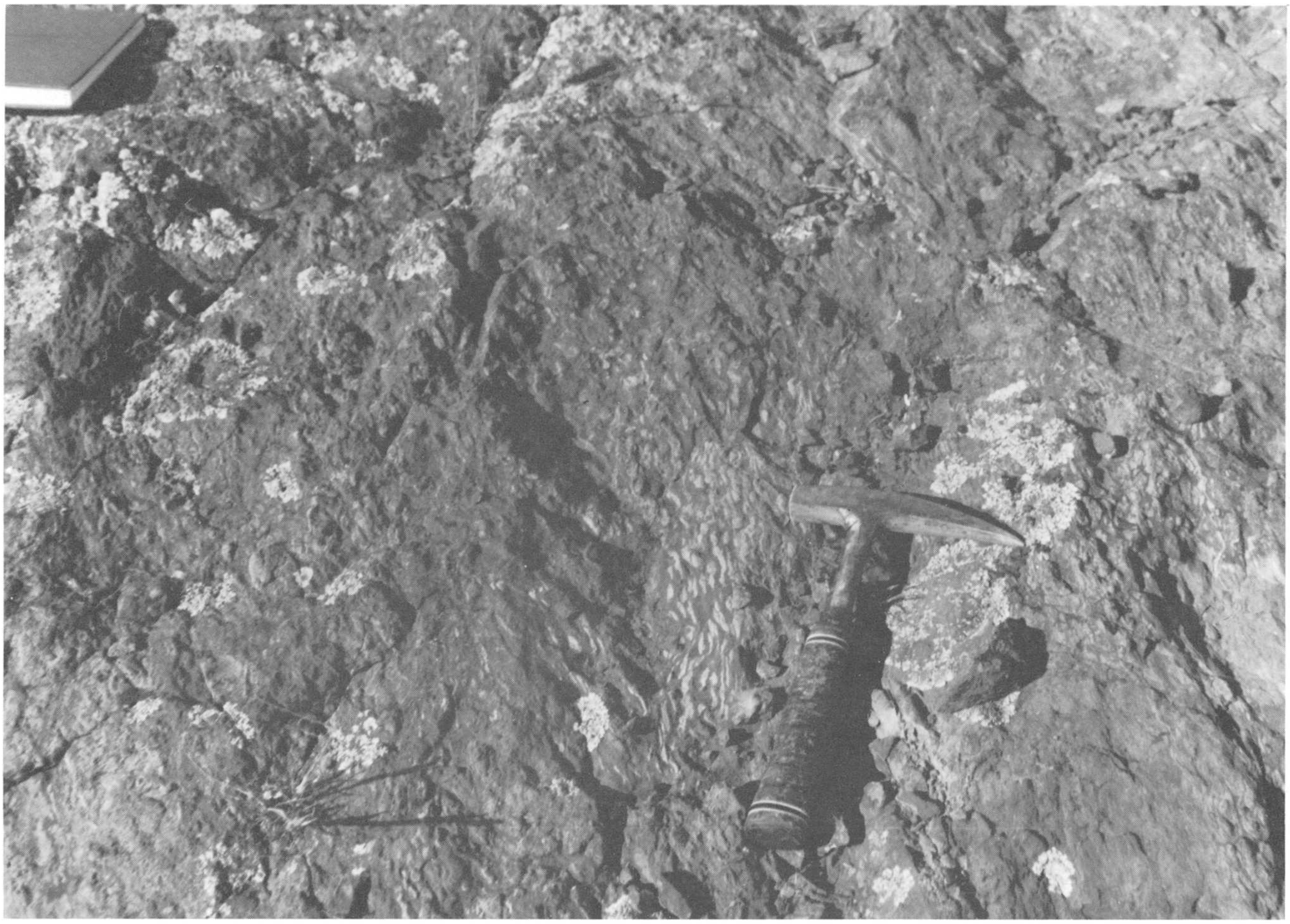

Figure 8. Lapilli tuff in northeastern part of map area.

Table 1. Major-element composition of selected rock samples from the Big Canyon area, El Dorado County, California
[Total iron reported as FeO; analyzed by X-ray fluorescence; A.E. Hubert, analyst]

Sample No.	Sample lithology	SiO_2	Al_2O_3	MgO	Na_2O	CaO	K_2O	FeO	TiO_2
1	Olivine basalt	45.63	18.01	6.52	1.86	12.40	0.59	14.56	2.14
2	Olivine basalt	47.05	14.18	11.65	2.06	9.55	0.23	12.33	1.14
3	Olivine basalt	44.29	13.52	7.17	2.67	8.42	0.31	14.10	2.34
4	Olivine basalt	49.51	14.63	7.72	2.94	8.57	0.53	11.48	1.29
5	Olivine basalt	47.28	14.72	9.31	2.17	9.64	0.11	14.42	1.70
6	Olivine basalt	45.72	17.96	6.15	2.34	12.08	0.27	11.64	1.60
7	Olivine basalt	48.82	13.58	8.92	2.23	8.80	0.15	15.26	1.74
8	Basalt	43.55	15.51	8.36	2.39	14.43	0.14	12.14	1.77
9	Basalt	40.43	14.70	7.98	1.86	18.66	0.08	10.99	1.65
10	Andesitic basalt	52.17	13.24	8.13	3.56	7.83	0.18	15.13	2.28
11	Basaltic tuff	47.81	20.10	5.53	3.15	10.60	0.13	10.52	1.10
12	Lapilli tuff	46.59	18.22	7.06	0.93	10.47	0.24	16.42	2.12
13	Hyaloclastite	48.31	28.18	2.07	3.09	11.51	0.53	7.51	0.68
14	Basaltic breccia	50.16	16.66	4.69	1.67	9.94	0.24	14.02	2.87
15	Amphibolite	56.97	15.25	6.56	5.86	4.60	0.22	9.13	0.53
16	Amphibolite	56.88	15.52	4.78	2.67	5.26	0.30	11.45	0.42
17	Serpentinized harzburgite(?)	43.55	0.10	38.10	0.10	0.02	0.10	8.96	0.01
18	Serpentinized harzburgite(?)	44.02	0.10	34.94	0.10	0.54	0.02	10.81	0.08
19	Serpentinite	42.59	0.47	32.61	0.10	1.09	0.02	9.04	0.04

sulfide content. Pyrite is by far the most abundant sulfide mineral, and trace amounts of arsenopyrite may be in the ore. Spectrographic analysis by B.M. Adrian and R.W. Baker that show as much as 500 ppm arsenic probably reflect small amounts of arsenopyrite. A trace of chalcopyrite was noted in one sample; however, the ore contains very low concentrations of copper and other base metals.

Pyritic carbonate alteration zones that are smaller than but similar to the zone at the Big Canyon mine occur at several faulted or sheared localities within the Big Canyon Creek fault zone (fig. 2). The mineralized locality in the southern part of the map area, locally known as the Live Oak mine, was developed by prospects. Core samples obtained by Gold Fields Mining Corp. from this locality reportedly contained gold values comparable to those at the Big Canyon mine (R. Ridler, oral commun., 1985). Outcrop samples collected from other carbonate alteration zones that were found during the course of the present studies contained less than 0.05 ppm gold.

Vandalia Mine

Pyritic banded iron-formation, pyritic ferruginous chert, and pyritic chert were mined for gold at the Vandalia mine in the northern part of the area shown in figure 2, and several localities of pyritic rocks in the detached chert blocks have been prospected for gold. The BIF occurs as intercalations in the chert and consists of alternating bands of magnetite and chert in units that are as thick as about 35 ft, south of the mine area. Apparently, the magnetic BIF grades laterally and vertically to hematitic ferruginous chert and then to iron-poor chert over a few tens of feet. In places, the iron bands, in addition to magnetite or hematite, contain fine- to medium-grained euhedral pyrite that composes as much as 10 percent of the rock. Pyrite also occurs in chert beds that are devoid of magnetite or hematite. Pyritic chert-BIF intervals are commonly about 6 ft thick and may persist along strike for several hundred feet; however, gold distribution in the pyritic beds, as judged from the assay results of outcrop samples, is apparently localized. In most places the BIF contains even, parallel laminations of magnetite and chert (fig. 5). At some localities where the BIF is gold-bearing, however, the laminae are deformed, and the BIF contains boudinage structures, small extension fractures, and detached folded laminae. Additional studies are needed to determine the relationship, if any, between the distribution of gold and the deformation features in the BIF. Gold-bearing chert and BIF at the Vandalia mine are underlain by a zone of extensive quartz veining. In places the veins are pyritic; however, none of the vein samples collected during the present studies contained a detectable amount (0.05 ppm) of gold. The spatial association of the veins with the ore zone suggests that they may represent a feeder zone, but direct evidence that would genetically link the veins to the ore zone is lacking.

The BIF at the Vandalia mine contains as much as 5,000 ppm manganese and as much as 100 ppm lanthanum, but it contains very low amounts of base metals. Gold-bearing core samples that are currently under study by J.T. Nash (written commun., 1986) contain as much as 2,700 ppm arsenic. Outcrop samples contained only normal amounts of arsenic, and no arsenopyrite was noted.

The chert and associated BIF are characteristic of chemical sediments formed by sedimentary exhalative processes in an island-arc setting. The association of gold with stratiform pyrite suggests that it was deposited during sulfurous emanations on the seafloor.

CONCLUSIONS

Gold occurrences in the Big Canyon area are in a subduction melange complex that trends northerly along the western flank of the Sierra Nevada. The area lies on the northerly projection of the melange belt as defined by Duffield and Sharp (1975) from outcrops south of the Cosumnes River, and it is within the Sierran ophiolite belt of Saleeby (1982). In the study area, the melange consists of small to large detached blocks as much as one mile in length of volcanic, volcaniclastic, and siliceous sedimentary rocks. The matrix of the melange is serpentinite and basaltic rocks that are vestiges of a dismembered ophiolite. Dismemberment of the ophiolite is inferred to have occurred during the formation of a submarine trench associated with the subduction of oceanic crust along the continental margin in early to middle Mesozoic time. During and shortly after trench formation, coarse debris flow deposits and large blocks of cherty and locally iron-rich sedimentary rocks with some interlayered felsic tuff filled the trench from island-arc terrane to the east, while debris flow deposits and slabs of basaltic rocks, all derived from oceanic crust, filled the trench from the west.

Two types of gold deposits occur in the Big Canyon area. The older deposits are represented by the Vandalia deposit which occurs with stratiform pyrite in chert and in banded iron-formation. The host rocks are a part of a thick sequence of mostly layered chert that occurs in the study area as detached blocks. The chert, BIF, and associated iron sulfide-gold deposits are inferred to represent sea-floor exhalites deposited east of the study area in an island-arc terrane of late Paleozoic to early Mesozoic age. Chert sequences indistinguishable from those in the study area have been described from the Paleozoic eastern belt (Duffield and Sharp, 1975). This suggests that cherts within and east of the Mother Lode belt may also be favorable targets for gold exploration.

The second type and younger of the gold deposits in the study area is represented by the Big Canyon deposit which, like occurrences in the Mother Lode belt to the east, is fault controlled (Landefeld, 1985). In the Big Canyon area, occurrences of this type are characterized by the effects of pyritization, silicification, and strong carbonate alteration in brecciated fault zones. The principal occurrences are associated with a major fault that trends parallel to Big Canyon Creek and forms the eastern margin of the melange belt. A zone of carbonate alteration in a relatively minor fault that branches from the Big Canyon Creek fault zone (fig. 2) may also be a favorable target for gold exploration, although outcrop samples from this alteration zone did not contain detectable amounts of gold. Structural relationships show that the gold-bearing breccia zones are younger than the formation of the melange and that, like the gold-quartz veins in the Mother Lode belt to the east, the breccia of the study area probably formed prior to the emplacement of the Cretaceous Sierra Nevada batholith.

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